ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Partial Report

On

THE ADEQUACY OF ARMORED FORCE WINTER CLOTHING

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Project Nos. 1-1, 1-4, 1-5, 1-6

January 18, 1943

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Fort Knox, Kentucky

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PARTIAL REPORT ON THE ADEQUACY OF ARMORED FORCE WINTER CLOTHING

1. **PROJECT: 1-(1,4,5,6) Test of the Adequacy and Ranges of Use of Winter Combat Clothing.**

a. Authority - Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, 400.112/6 GNOHD, dated September 24, 1942.

b. Purpose - To determine the adequacy and ranges of use of Armored Force Winter combat clothing.

2. **DISCUSSION:**

a. Methods - The studies were carried out in the cold room at temperatures ranging from ±10° F to -30° F. Experiments were conducted for the most part in still air, so as to provide the least severe cooling conditions likely to be encountered. Details of the experimental procedure and the data obtained are given in the appendix.

3. CONCLUSIONS:

a. The Armored Force winter combat uniform consisting of combat jacket; trousers; combat helmet, winter; overshoes, 4-buckle, arctic; and gloves, flying; supplemented with 2 suits of woolen underwear; 3 pairs of woolen socks and other articles of personal equipment (OD trousers, etc.,); will keep resting men warm for one (1) hour at an average temperature of +5 F.

b. The winter combat uniform is adequate for men doing moderately hard work at temperatures as low as -20°F., but only while the men keep working.

c. Ventilation of the winter combat uniform is inadequate to prevent accumulation of moisture. Ventilation can only be secured by opening the jacket and overalls. The lower part cannot be ventilated.

d. Defecation and urination require excessive exposure of the body.

e. The fastening of the winter combat helmet is poor. The helmet cannot be fastened if gloves are worn.

f. The helmet does not provide sufficient protection for the face and neck.

g. None of the issue gloves or combinations thereof were adequate at the temperatures of this study.

h. Even when supplemented with 4 pairs of socks (1 cotton, 1 medium wool, and 2 arctic) in the 4-buckle rubber arctics, protection for the feet was inadequate for more than one (1) hour at rest at -30° F. The toes were in danger of freezing within an hour.

i. Knees are poorly protected and frequently cause as much discomfort as do the toes.

j. Supplementing the winter combat uniform as indicated below will keep sitting, resting, men comfortably warm in quiet air, (with occasional breeze) for periods up to one and one-half (1½) hours at the temperatures noted. The limiting factor in most instances is the lack of sufficient protection for the feet and hands.

<u>Temperatures 0° to -10°F</u>

(1) Two pair wool socks, arctic
(2) Parka, alpaca lined (windproof outer cover hood is also lined with alpaca)
(3) Toque
(4) Wool gloves
(5) Fur mittens (these are not practical. For the purpose of the experiment they were used to keep the hands warm enough to continue the test).

<u>Temperatures -10° to -30°F</u>

(1) As above
(2) Turtle-neck sweater
(3) Innersoles

4. <u>RECOMMENDATIONS</u>:

a. That the present Winter Combat Uniform with modifications, be retained pending the initiation and completion of experimental studies on new models. This recommendation is extended since the difficulty with the present suit lies primarily in the inadequate protection of the extremities.

b. That types of clothing other than those now issued be investigated for their suitability to the needs of the Armored Force when operating

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4. RECOMMENDATIONS:

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b. That types of clothing other than those now issued be investigated for their suitability to the needs of the Armored Force when operating in sub-freezing environments.

c. That when arctics are worn, arctic socks and innersoles be substituted for GI shoes which are contra-indicated during cold weather.

d. That medium length arctic sock or equivalent be standardized.

e. That until more complete studies are carried out, the present winter combat uniform be modified in the following respects:

(1) Provision be made for defecation and urination without excessive exposure being necessary. ✓

(2) That openings be provided on the left side of the trousers similar to those on the right.

(3) That zipper tabs be provided with thongs that can be handled with gloved hands.

(4) That a suitable fastener be provided for the chin strap on the combat helmet. Fasteners of metal should not be in contact with the skin, and should be capable of being easily fastened with gloved hands. ✓
(Note: Winter Operations Board urgently requested this change 10 months ago!).

f. That the following changes be made in the parka, alpaca lined:

(1) ✓ The belt be attached.

(2) The zipper be provided with thongs.

(3) The facepiece be provided with fasteners capable of being easily fastened with gloved hands.

(4) The present breast pockets be lined with alpaca or other material to provide auxiliary protection for the hands.

(5) Additional pockets in the lower portion be added.

Submitted by:

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APPENDIX

1. INTRODUCTION:

Many clinical studies on men who have experienced prolonged cold have shown clearly that the desire for warmth is overwhelming. Men will not endure severe cold with suffering even if it means sacrifice of duty. If warmth cannot be obtained, deterioration is rapid and there is complete indifference to danger and responsibility.

Clothing should be adequate to maintain an average body skin temperature of from 85° to 93° F. When the average skin temperature drops below this point, discomfort begins. With skin temperature below 80° F on the torso, and toe temperatures of 47° or 48° F, there is marked discomfort. The latter temperature is near the critical temperature for the toes. If the skin temperature on the toes remains at 45° F for more than an hour, injury may ensue, below 40° F frostbite may occur at anytime if the exposure is continued.

Despite clothing, some fall of skin temperature and/or rectal temperature is inevitable with exposure to cold, but no clothing should be considered satisfactory for use by the Armed Forces unless it will protect men sufficiently to prevent the temperature of the skin of the trunk from falling below 85°F or the skin of the extremities below 55° F. Such criteria should be met by test under the conditions in which the clothing is to be used. If men are to be transported at rest in vehicles, or be confined within armored vehicles for periods of hours, then the clothing ought to be adequate to prevent suffering when tested under these conditions. The clothing must, moreover, be so designed as to permit operation of the vehicle and its weapons.

2. EXPERIMENTAL PROCEDURE:

In this first set of experiments an attempt was made to reproduce conditions that will be encountered by men who are forced by the nature of their duties to restrict their activity. The experiments were conducted in a refrigerated room with temperatures between +10° and -30°F.

The greatest portion of each experiment was conducted in still air so as to provide the least severe conditions for the cooling of the body. (Additional experiments are being made during which crews of various types of vehicles are exposed to wind velocities reaching 50 M.P.H.).

The clothing was worn by men who sat until they became too cold to continue. They were then walked around the room at a rate of approximately 2.5 miles per hour until warmed up. In most cases they again sat until they became dangerously cold whereupon the experiment was terminated. Skin and rectal temperatures were measured and subjective estimates of comfort and shivering were obtained periodically.

Results: *The first experiment, conducted at an average temperature of +5° F., indicated that the Armored Force Winter Combat Uniform is not adequate for maintaining resting men in comfort for periods much longer than one hour.* In 3 out of 4 cases shivering occurred within one and one-quarter (1¼) hours. The uniform, however, proved quite adequate as long as men were engaged in moderate activity. Additional observations showed that this uniform would keep men comfortably warm at temperatures as low as -10° to -20° F., if the men were engaged in moderately hard work. Comfort could only be maintained by continued work.

Since Armored Force personnel must operate at temperatures as low as -30° F., a number of experiments were conducted in still air at temperatures of 0°, -10°, -20° and -30°F. In these experiments the Combat Uniform was used as a basis to which other articles of clothing were added. For the experiment at 0°F., an alpaca lined parka, two pairs of wool socks, arctic, and 4-buckle arctic overshoes were added.

A generalized statement of the symptoms observed at 0°F follows in order of appearance:

1. Knees - cold within one-half (½) hour.
2. Toes and heels (and in some cases feet) cold within one (1)hour.
3. Toes are painfully cold within one and one-quarter (1¼) hours.
4. Shivering, in some cases vigorous, within one and one-half (1½) hours.
5. Walking became necessary for warmth.
6. In general, the subjects warmed up after 15 minutes of walking.
7. After one-half (½) hour of walking the subjects were able to sit again with reasonable comfort for another hour. However, some men cooled off very rapidly after the exercise. This point will be discussed in detail later.

The addition of the alpaca lined parka helped greatly in keeping the body warm. The extremities were the first to suffer from the cold and caused the greatest degree of discomfort. There is a definite need for further study of means of protecting the extremities.

The clothing used at 0° F was also tried at -10° F. The results were similar, with one major exception. The body cooled off rapidly and after 1 hour in one case and 1½ to 2 hours in the others. The subjects were uncomfortably cold, were shivering vigorously and had to walk for a longer period to get warm. On returning to the resting position, they cooled off very rapidly and had to retire from the experiment within 45 minutes due to extreme pain in the extremities. The presence of dampness and formation of frost on the inner surface of the arctic overshoes appeared to be a large contributary factor to this discomfort.

For tests conducted at -20° F., a turtle neck sweater was added to the combination of clothing worn at -10° F. Some of the subjective responses

of a subject, L. E., at -30° F. are presented in Protocol #1. Note that the extremities were again the first to cool and that with continued exposure the pain and discomfort resulting from the cold extremities were outstanding symptoms and held the primary attention of the subject. Attention was focused on his uncomfortable extremities and interest in other events suffered. The body began to cool within an hour but was relieved by shivering from continuing its downward trend. This subject had only a slight lowering of body temperature (probably being kept elevated by his shivering). (Fig. I). The rapid and extensive alteration in the skin temperature of the toes, a 50 degree drop in approximately one and one-half (1½) hours, is typical for the insulative protection given to all of our subjects' extremities. L. E.'s feet (toes particularly) warmed very slowly during his walk. At the cessation of 50 minutes of exercise the skin temperature of his toes had been raised only 22 degrees F. However, they were in a fairly comfortable range and his subjective reactions indicated warm toes. It whould be noted that subjective sensations are only indicative and may be far from actual values, usually they lag behind recorded temperatures of particular areas. It was again noted following the exercise that the arctic overshoes were damp. This moisture-retaining property of the arctics is the primary reason for their failure as protective footwear in cold. The accumulation of water leads to more rapid cooling of the toes and foot since water is an efficient conductor of heat.

Experiments were also conducted at -30° F. The clothing worn was similar to that used at -20° F., with the exception that burlap or felt innersoles were added to provide additional protection for feet. This experiment was conducted after a period of mildly cold weather. All of our subjects but one had practically identical responses. Toes, knees, heels and fingers were quite cool within the first twenty minutes of exposure and shivering was vigorous at the end of one hour. In one subject, shivering started after 15 minutes of exposure and rapidly became quite violent. Despite excessively hard shivering, his extremities were painfully cold at the end of one hour. All but one subject (W. J., who did no walking), walked for 20 minutes which was sufficient to elevate the temperature of the toes to comfortable levels. On returning to a sitting position, there was a rapid cooling of the extremities and of the body. Shivering became vigorous despite which the toes became so unbearably painful that the experiment had to be terminated.

One subject, (W. J., Fig II), was able to remain sitting quietly for two and one-half (2½) hours. During the first hour there were no symptoms of cold except for slight chilliness of knees and fingers. After that the toes began to cool off rapidly and by 2½ hours the thighs, as well as the fingers were quite cold. There was a slow steady decrease in his rectal temperature, a fall of 2.0°F. The skin temperature of the chest remained constant for nearly two hours and then began to fall. The skin temperature of his great toe fell slowly but steadily. At the end of two hours and 25 minutes, it had dropped to levels of severe discomfort and the subject had to leave the room. The skin temperature of index finger and the palm were practically identical for the first hour and then began to diverge, the index finger becoming colder while the palm leveled off.

In Fig. III is shown the rather atypical response of one of our subjects. He was the only subject that did not complain to any great extent of cold at -10° F and was experiencing no apparent discomfort. While there was a drop in the temperature of his extremities, it was not extreme. The skin temperature of the subject's toes after 2 hours was 65° F while after the same interval of time in other subjects the toe skin temperatures were as low as 45° F. An explanation can be found in the rectal (or body) temperature changes. H.G.'s rectal temperature dropped approximately 3° F in contrast to falls of not more than 0.5° F in any of the other subjects.

GENERAL COMMENTS ON THE CLOTHING TESTED: The primary defect of Armored Force Winter Clothing is the inadequacy of the protection given to the extremities. The question of gloves is particularly pressing and vital, since it affects all personnel especially those whose work entails delicate manipulations. The feet are another poorly protected portion of the body, and better means of protection must be devised. Whether this can be accomplished by
1) better insulation, or by heating the toes with electrically heated socks is
unimportant. The need for protection is imperative. The use of shoes in
2) cold weather is definitely contraindicated. The ordinary GI shoe offers too
3) many opportunities for impeding the circulation, since men have a tendency to put on as many socks as possible and so fill the shoe to capacity.

Other comments have to do primarily with minor inconveniences in the design of the clothing. These can be readily corrected. In the combat trousers no provisions have been made for urination or defecation without excessive exposure of the body. The combat trousers fit too closely to the knee when sitting, and the knees become cold quickly.

The zipper tabs cannot be readily handled when the fingers are gloved and numbed from cold. The combat helmet offers little protection to face and neck, especially if there is a breeze and the wool lining irritates the skin. The method of fastening the chin strap is impractical. It is difficult to fasten even under the best of conditions and impossible if gloves or mittens are worn.

PROTOCOL #1

Room Temperature -20° F

Subject L. E. Height 6'1" Weight 170 lbs Age 34

Clothing Worn

(1 pair cotton underwear
(2 pair woolen underwear
Body(1 Winter Combat Uniform (Jacket, Trousers, Helmet)
(1 Turtle neck woolen sweater
(1 Parka, Overcoat Alpaca Lined
(1 Wool Toque
(1 pair light cotton stockings
Feet(2 pair arctic socks, wool
(1 pair 4 buckle arctic overshoes
(1 pair woolen gloves
Hands(1 pair fur mittens

Time Minutes	Body	Shivering	Toes	Legs	Trunk	Hands Fingers	Face	Rectal Temperature	Comments
0	-	-	-	-	-	-	-	99.0	
5	-	-	-	Knees Cold	-	-	-	-	
17	-	-	-	Knees Cold	-	-	-	100.4	
36	Cool	-	Cool	Cool	Cool	-	-	99.8	
60	Cold	Occasional	Cold	Cool	Cool	Cool	Cool	-	
65	Cool	Mild	Cold	Cool	Cool	Cool	-	99.4	
70	Cool	Mild	Very Cold	Cold	Cool	Cool	Cool	-	Not so cold except feet

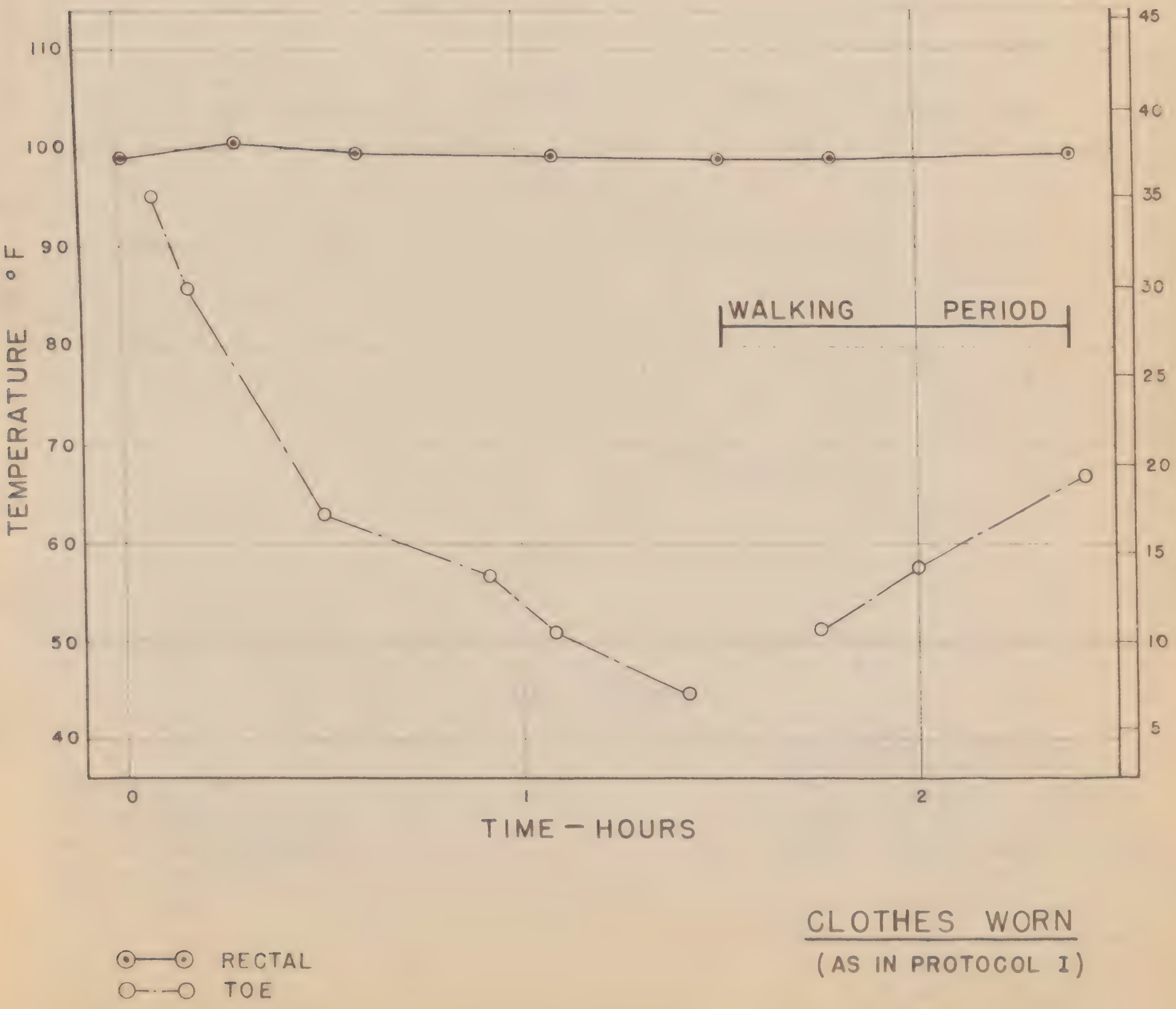
PROTOCOL #1 (Continued)

Time Minutes	Body	Shivering	Toes	Legs	Trunk	Hands Fingers	Face	Rectal Temperature	Comments
80	Cool	Mild	Very Cold	Cool	Cool	Cool	Cool	-	Pretty good generally but feet and toes bad
90	Cool	Mild	Painful	Cool	Cool	Cold	Cool	99.2	Started to walk
					WALKING				
100	Comfortable	None	Slightly numb	-	Cool	Cold	Cold	99.0	Still walking
130	Comfortable	-	Warm		Warm	Warm	Warm	-	Still walking
150	-	-	-		-	-	-	99.6	Warm all over
152			Experiment Terminated						

FIG. I

BODY AND SKIN TEMPERATURES (SUBJECT L. G.)

SITTING AND WALKING AT −20°F. 11−19−42



CLOTHES WORN

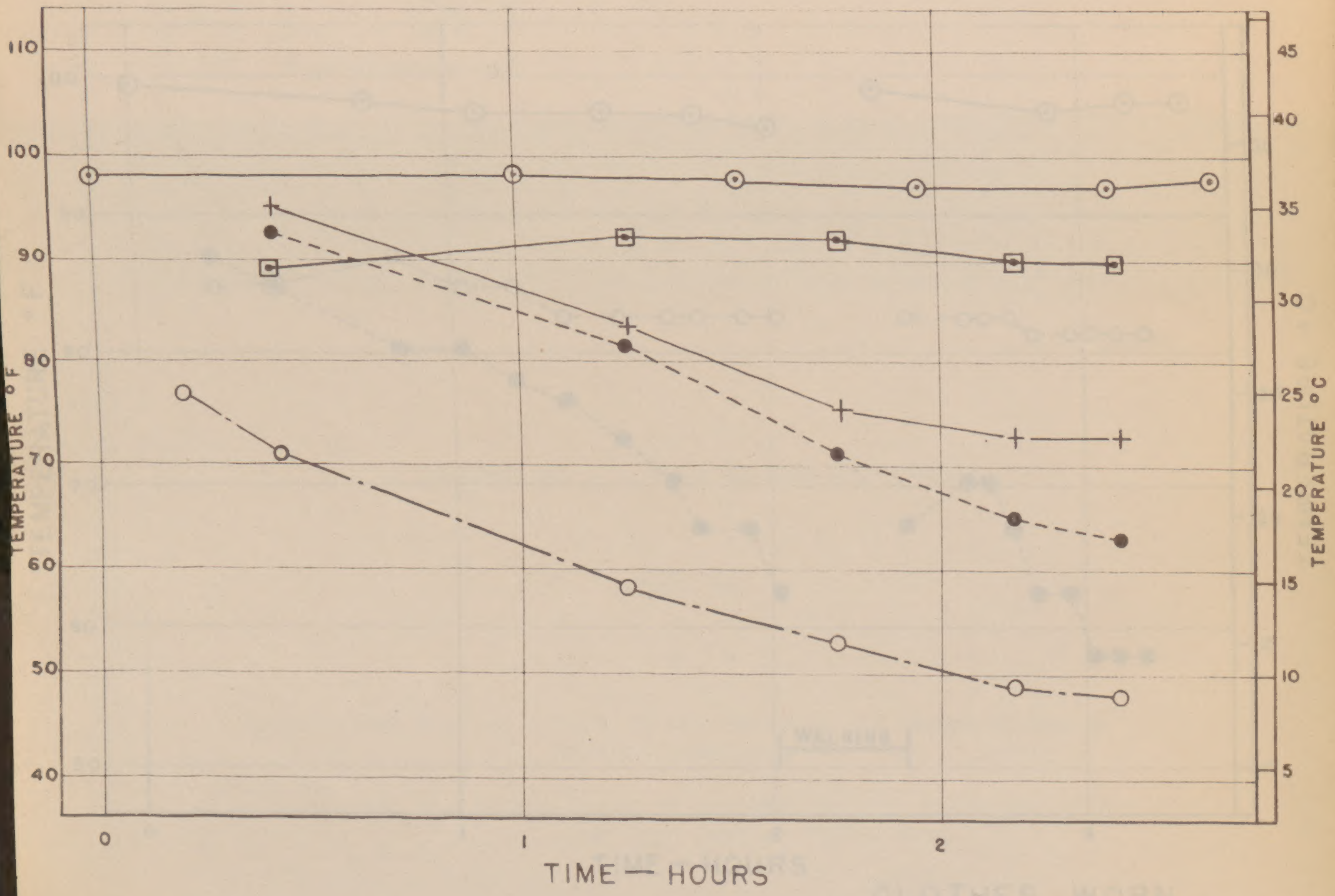
(AS IN PROTOCOL I)

FIG. I

FIG. II

BODY AND SKIN TEMPERATURES (SUBJECT W. J.)

SITTING AND WALKING AT −30° F. 12-24-42



CLOTHES WORN

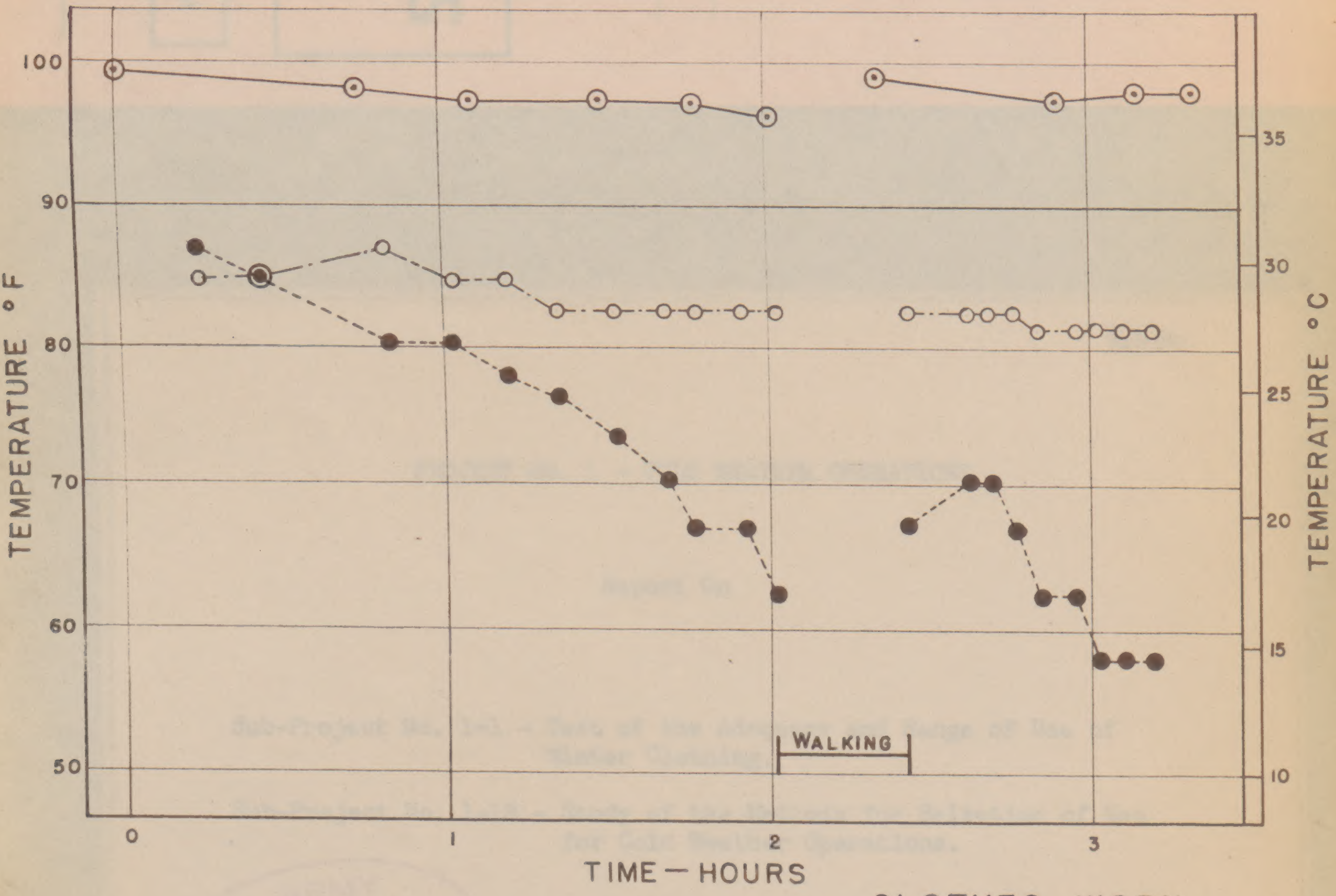
1 PR.	4 BUCKLE ARCTICS
1 PR.	G.I. WOOL SOCKS
2 PR.	ARCTIC WOOL SOCKS
1	TURTLE NECK SWEATER
1 PR.	COTTON SHORTS
2 PR.	WOOL UNDERWEAR
1	COMBAT UNIFORM
1	PARKA, ALPACA
1	TOQUE
1 PR.	FUR MITTENS
1 PR.	WOOL GLOVES

FIG. II

FIG. III

BODY AND SKIN TEMPERATURES (SUBJECT H.G.)

SITTING AND WALKING AT −10 °F. 11-20-42



CLOTHES WORN

1 PR.	4 BUCKLE ARCTICS
1 PR.	G.I. WOOL SOCKS
1 PR.	ARCTIC WOOL SOCKS
2 PR.	HEAVY WOOL SOCKS
1	TURTLE NECK SWEATER
2 PR.	WOOL UNDERWEAR
1	COMBAT UNIFORM
1	PARKA, ALPACA
1	FUR TRIMMED PARKA
1 PR.	FUR MITTENS
1 PR.	WOOL GLOVES

FIG. III